Map Unit Properties Table: Saugus Iron Works National Historic Site

Colored map units are mapped within Saugus Iron Works National Historic Site. Bold text refers to sections in report.

Age	Map Unit (Symbol)	Geologic Description	Geologic Features and Processes	Geologic Resource Management Issues	Geologic History
PROTEROZOIC? TO JURASSIC?	Diabase dike with magnetite (**ZJ(?)db**)	Diabase is an intrusive igneous rock with a relatively low silica content whose primary mineral constituents are labradorite and pyroxene. In the Saugus Iron Works area, **ZJ(?)db** is fine to medium grained, black to gray, with light brown weathered surfaces. Prominent, scattered magnetite crystals give rock surfaces a sandy texture. Locally, dikes are oriented east to west with some sets trending north to south. Weathered surfaces of **ZJ(?)db** have erratic magnetic polarization, possibly due to modern lightning strikes.	**Igneous Rocks**—**ZJ(?)db** is part of a suite of intrusive igneous dikes in the Saugus area and throughout eastern Massachusetts.	None reported	**Pangaea Rifts Apart and Weathering Commences**—some of **ZJ(?)db** may be associated with the rifting apart of Pangaea during the Mesozoic, but relative age relationships with rocks at some outcrops suggest a Proterozoic age.
DEVONIAN	Peabody Granite (**Dpgr**) Peabody Granite, brecciated (**Dpgrb**)	"Granite" denotes a specific intrusive igneous rock composition characterized by relatively high silica contents, rich in quartz (10 to 50%) and with more alkali feldspars than granodiorite. Other minerals include plagioclase, muscovite, biotite and/or hornblende. In the Saugus Iron Works area, **Dpgr** and **Dpgrb** are coarse grained with a light pinkish gray color. Orthoclase (alkali feldspar) composes up to 55% of the total rock, quartz is between 42% and 53%, with trace amounts of augite and riebecktite minerals. Very few alteration textures seen in **Dpgr**. **Dpgrb** is broken into a chaotic mix of grains surrounded be a fine-grained matrix associated with deformation along local fault zones.	**Faults**—**Dpgrb** is a mappable zone of intensely deformed rocks along major local faults. **Igneous Rocks**—**Dpgr** is a distinctive, discrete member of a suite of intrusive igneous rocks in the Saugus area. **Radiometric Age Dates**—**Dpgr** is 378±0.62 million years old and 395±2 million years old by Uranium-Lead series dating.	None reported	**Mountain Building, Terrane Accretion, and the formation of a Supercontinent**—**Dpgr** may have been emplaced during the continental collisions of the Acadian Orogeny, one of three major orogenies that built the Appalachian Mountains. After its emplacement, zones of **Dpgrb** formed during mountain-building orogenies, most likely the Alleghany Orogeny.
PROTEROZOIC TO DEVNONIAN	Quartz-diorite and diorite (**ZDd**)	Diorite is a relatively silica-poor (mafic) igneous rock with moderate silica content with plagioclase feldspar, hornblende, and biotite with only scant quartz. Locally, **ZDd** is fine to medium grained, dark gray to black with abundant, shiny black biotite crystals. Dark minerals compose about 50% of the total rock. Primary mineral constituents include albite, quartz, orthoclase, biotite, hornblende, diopside, apatite, and ilmenite. Very little secondary alteration occurs in **ZDd**. Injections of red alkali-feldspar granite and pegmatite occurred locally. **ZDd** includes bodies of gabbro. Gabbro was used as a flux agent in the iron works operations at Saugus.	**Radiometric Age Dates**—age dates for **ZDd** include 392±4 million years old, 488.53±0.81 million years old, and 488.48±0.79 million years old (all using Uranium-Lead series dating technique). Additional correlation and dating are necessary to determine the age and relationships among the many diorites and gabbroic intrusive rocks in northeastern Massachusetts.	None reported	**Mountain Building, Terrane Accretion, and the formation of a Supercontinent**—the timing of formation of these units is not well constrained. They are part of a suite of igneous intrusive rocks that compose the Avalon terrane. After emplacement of **ZDgdt**, zones of **ZDgdtfb** formed during mountain-building orogenies.
	Aplitic granodiorite (**ZDgdta**)	"Granodiorite" refers to an igneous intrusive rock that is typically coarse grained and dominated by quartz, plagioclase, and potassium feldspar minerals with some biotite and hornblende as the minor, dark-colored mineral components. The term aplitic refers to the texture of the rock, in this case resembling sugar without significant dark minerals or flaky mica grains. In the Saugus Iron Works area, **ZDgdta** is very fine grained and a light pinkish gray color. It resembles **ZDgdt** in composition, but with a much finer texture.	**Igneous Rocks**—**ZDgdta** is part of a suite of intrusive igneous rocks in the Saugus area.		
	Tonalite to granodiorite (**ZDgdt**) Tonalite to granodiorite, fault breccia (**ZDgdtfb**)	Tonalite is a silica-rich (felsic) intrusive igneous rock with a specific composition rich in plagioclase and quartz, but with little potassium feldspar or mica minerals. Granodiorite is described under **ZDgdta**. In the Saugus Iron Works area, **ZDgdt** is fine grained and light to dark gray with uniformly shaped crystals. Mineral constituents include oligoclase (25–55%), orthoclase or microcline (0–15%), quartz (30–60%), hornblende, and biotite. Many primary minerals are altered and/or strained. **ZDgdtfb** is broken into a chaotic mix of grains surrounded be a fine-grained matrix associated with deformation along local fault zones.	**Faults**—**ZDgdtfb** is a mappable zone of intensely deformed rocks along major local faults. **Igneous Rocks**—**ZDgdt** is part of a suite of intrusive igneous rocks in the Saugus area.		

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Age	Map Unit (Symbol)	Geologic Description	Geologic Features and Processes	Geologic Resource Management Issues	Geologic History
NEOPROTEROZOIC TO LOWER CAMBRIAN	Boston Bay Group: Roxbury Conglomerate and Cambridge Argillite, undifferentiated (**ZCrcca**) Boston Bay Group: Argillaceous sandstone and siltstone and Cambridge Argillite, undifferentiated (**ZCrsca**)	"Argillite" is a general term for a compact rock derived from mudstone, siltstone, and/or shale that has been slightly metamorphosed, but lacks strong cleavage or fissility (propensity to break or splinter along planes). **ZCrcca** and **ZCrsca** are not well exposed in the Saugus Iron Works area. The lowermost members consist of pebble to cobble conglomerate with rare boulders and thick, massive bedding. Clast types include volcanic rocks, quartzite, and granite surrounded by a sandstone to argillite matrix. The conglomerate grades upward into an argillite dominated by gray, buff, to locally purple sandstones, quartzites, and siltstones. Diamictites, or pebbly to conglomeratic mudstones, occur within the argillite. Bedding structures range from laminated to massive.	**Sedimentary Rocks**—flat-lying pebbles indicate the plane of bedding in the conglomerate. Diamictites are terrestrial rocks of mixed size, unrounded, and unsorted clasts with enigmatic origins. Generally, they are rocks whose sediments are derived very closed to their source. They may record deposition of till during an ancient glaciation or landslide deposits. **Radiometric Age Dates**—a volcanic ash bed within the Cambridge Argillite was dated to 570 million years ago using Uranium-Lead series dating of zircons. **Paleontological Resources**—the Cambridge Argillite contains acritarch microfossils common at the end of the Neoproterozoic.	None reported	**Formation of the Avalon Terrane and its Detachment from Gondwana**—The Boston Basin opened as a rift valley when the Proterozoic supercontinent Rodinia broke apart. The lowermost beds of the Boston Bay Group are younger than 593 million years. The Boston Basin collected sediments into the Early Cambrian.
NEOPROTEROZOIC ERA	Quartz keratophyre and keratophyre (**Zvk**)	A keratophyre is a metamorphic rock dominated by sodium-rich feldspar, chlorite, epidote, and calcite. Keratophyres tend to occur in association with marine sediments and submarine basalts. **Zvk** occurs as massive flows, breccias, pillow lavas, and laminated devitrified (crystallized glass) palagonite-tuff. They intergrade with **Zlv** to the east.	**Volcanic Rocks**—**Zvk** contains pillow lavas indicating submarine volcanism.	None reported	**Formation of the Avalon Terrane and its Detachment from Gondwana**—**Zvk** was deposited as a mix of volcanic and marine sedimentary layers atop a subduction zone that also gave rise to many of the intrusive igneous rocks in the area during the time the Avalon terrane was forming on the northwestern edge of Gondwana.
NEOPROTEROZOIC ERA	Lynn Volcanics (**Zlv**) Lynn Volcanics, fault breccia (**Zlvfb**)	Rhyolite is an extrusive igneous rock with a mineralogical composition similar to granite. Textures include visible crystals in a glass to cryptocrystalline groundmass. If the alkali feldspar component decreases, rhyolite grades into rhyodacite. **Zlv** comprises rhyolite and rhyodacite flows, welded-ash flows, flow breccias, breccia pipes, extrusion domes, and vitric, lithic, and lapilli tuffs. **Zlv** appears black, red, white, cream, and shades of reddish and greenish gray. Bedding of successive flows is generally massive with some fine flow lamination in welded ash flows. **Zlvfb** consists of areas of **Zlv** which have been extensively faulted into a heterogeneous mix of large clasts in an extremely fine-grained fault gouge matrix. **Zlv** is the only geologic map unit within Saugus Iron Works National Historic Site.	**Fluvial Features and Processes**—**Zlv** forms part of the fall line that causes higher energy flow of the Saugus River. **Faults**—**Zlvfb** is a mappable zone of intensely deformed rocks along major local faults. **Volcanic Rocks**—features such as welded-ash flows, tuffs, flow breccias, and breccia pipes record silica-rich, explosive volcanism. **Radiometric Age Dates**—Uranium-Lead series dating of **Zlv** rhyolite exposed within Aggregate Industries quarry in Saugus indicates an age of 596 million years ago.	**Coastal Vulnerability to Sea-Level Rise and Climate Change**—**Zlv** underlies the entirety of Saugus Iron Works National Historic Site. Surficial geologic map coverage, including the depth to bedrock (**Zlv**) would be a valuable dataset for modeling the river channel's response to sea-level rise. This mapping would both delineate how the system responded to sea level fluctuations in the past, and determine the exact composition of the substrate, which would in turn help understand how it may react to factors such as increased erosion, water saturation, and tidal changes. **Disturbed Lands and Mineral Extraction**—**Zlv** is mined as aggregate material southwest of Saugus Iron Works National Historic Site.	**Formation of the Avalon Terrane and its Detachment from Gondwana**—**Zlv** was deposited by a volcanic arc atop a subduction zone that also gave rise to many of the intrusive igneous rocks in the area during the time the Avalon terrane was forming on the northwestern edge of Gondwana. **Zlv** is locally in fault contact with the Boston Bay Group (**ZCrcca** and **ZCrsca**), but elsewhere show a gradational, conformable relationship. **Zlv** is the extrusive (volcanic) equivalent of granitic-composition rocks emplaced between 625 million and 590 million years ago. **Zlv** lies nonconformably on rocks of **Zgr**, **Zgdm**, **ZDgdt**, and **Zgrt**. After its emplacement, zones of **Zlvfb** formed during mountain-building orogenies.
PROTEROZOIC EON	Quartzite and Olistostromal Assemblage (**Zqo**)	An olistostrome is the rock resulting from underwater landslides or slumping of unconsolidated sediments characterized by a chaotic mass of intermixed heterogeneous materials. **Zqo** consists of dark, metamorphosed siltstones, mudstones, and very fine-grained sandstones. Parts of Zqo are slump folded and contain irregular masses of meta-quartzarenite (olistostromes). The olistostromes contain massive, moderately to well-sorted, medium-grained, muscovitic (mica-rich) quartzite. Extensive faulting separates **Zqo** into uncorrelatable blocks.	**Sedimentary Rocks**—olistostromes record submarine slope movements. **Radiometric Age Dates**—Uranium-Lead series dating of zircons at the type locality indicates **Zqo** was deposited about 600 million years ago.	None reported	**Formation of the Avalon Terrane and its Detachment from Gondwana**—In the Saugus Iron Works area, **Zqo** is intruded by **Zgr**, **Zgdm**, **ZDgdt**, and **Zgrt (**members of the "Dedham" granite), meaning that **Zqo** is older than those units.

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PROTEROZOIC EON	Mafic metavolcanic xenoliths of unknown affinity (**Zmu**)	A mafic xenolith is a fragment of silica-poor, iron- and magnesium-rich rock within an intrusive igneous rock mass. **Zmu** occurs as mappable blocks within **ZDgdt** and **Zlv**. The xenoliths are characterized by fine-grained, dark gray to greenish gray or black mafic metavolcanic rocks. The major mineral constituents include plagioclase (30–50%), hornblende (50–70%), and opaque minerals that are equigranular or roughly equivalent in size. Irregular clots and veinlets of granite, quartz, and epidote occur throughout the xenoliths.	**Metamorphic Rocks**—**Zmu** exhibits metamorphic foliation (or banding of aligned minerals) that parallels adjacent bedding or layering structures in the surrounding rocks.	None reported	**Formation of the Avalon Terrane and its Detachment from Gondwana**—**Zmu** xenoliths are found within **ZDgdt** and **Zlv** meaning **Zmu** is older than **ZDgdt** or **Zlv**.
	Trondhjemite (**Zgrt**)	Trondhjemite is a light-colored, intrusive igneous rock rich in sodic plagioclase (oligoclase), quartz, sparse biotite, and little to no alkali feldspar. It is named for a city in Norway. In the Saugus Iron Works area, **Zgrt** is coarse grained, light gray with many deformation features. Compositionally, oligoclase is about 50%, orthoclase is less than 10%, and quartz is about 40% of the rock. **Zgrt** is altered with oligoclase becoming sericite, strained quartz, hornblende becoming chlorite, and biotite becoming chlorite.	**Igneous Rocks**—These units are part of a suite of intrusive igneous rocks in the Saugus area.	None reported	**Formation of the Avalon Terrane and its Detachment from Gondwana**—**Zgrt** intrudes the surrounding volcanic rocks meaning that is it younger than those rocks.
	Granodiorite to quartz monzonite (**Zgdm**)	"Monzonite" refers to an intrusive igneous rock composed primarily of equal amounts of alkali feldspar and plagioclase, scant quartz, and augite as the primary dark-colored mineral. Granodiorite is described under **ZDgdta**. Locally, **Zgdm** is fine- to medium-grained light gray to pink and green in color. Approximately 50% of the rock is oligoclase, orthoclase (an alkali feldspar) is 20–40%, quartz is 20–30%. **Zgdm** is highly altered with chlorite, epidote, sericite, and sphene as secondary minerals.			**Formation of the Avalon Terrane and its Detachment from Gondwana**—**Zgdm** intrudes the surrounding volcanic rocks meaning that is it younger than those rocks. In some places, the relationship appears nonconformable and thus the timing of its emplacement relative to **Zlv** is locally unclear.
	Granitoidal rocks, undifferentiated (**Zgr**)	The term "granitoids" refers to general bodies of intrusive igneous rocks dominated by quartz and feldspars. In the Saugus Iron Works area, **Zgr** consists of fine- to coarse-grained, alkali granite to gabbro in colors varying between light and dark. **Zgr** includes bodies of gabbro. Gabbro was used as a flux agent in the iron works operations at Saugus.			**Formation of the Avalon Terrane and its Detachment from Gondwana**—**Zgr** was part of a series of igneous intrusions that formed part of the Avalon Terrane when it was still attached to the northwestern edge of Gondwana during the Proterozoic.